# INDUCTOR FOR SEMICONDUCTOR DEVICE AND METHOD OF MAKING THE SAME

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## BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a semiconductor device and method of making the same. In particular, the present invention relates to a semiconductor device including spiral inductors for an integrated circuit and method of making the same.

2. Description of the Prior Art

In forming a semiconductor device, use of individual devices such as transistors, resistors, inductors etc. are indispensable. Among them, it is difficult to make the inductors since they are more complicated in structure than other devices.

FIGs.1 to 4 are perspective views for explaining a conventional method of making inductors in a semiconductor device, which incorporates U.S. Patent No. 3,614,554 (Title of Invention : "Miniaturized Thin Film Inductors For Use In Integrated Circuits", Application No. 770,375). After collectors 13 of integrated circuits are formed in a semiconductor substrate 10 according to a design rule, the surface of the substrate is covered with a first insulating layer 12, and then conductive collector terminals 15 are formed which connect to the collectors 13. Then, after a first to an eighth underlying conductive lines 14a to 14h constituting conductors are formed of metal materials (FIG. 1), an oxide film 16 is formed to cover the surface of the substrate on which the first to the eighth underlying conductive lines 14a to 14h are formed, and then a bar 18 of magnetic materials is formed in order to cross the first to the eighth underlying conductive lines 14a to 14h (FIG. 2).

Thereafter, a second insulating layer 20 is formed to cover the surface of the substrate on

which the bar 18 is formed, and then a first to a eighth contact hole 22a to 22h that expose one ends of the first to the eighth underlying conductive lines 14a to 14h and a ninth to a fifteenth contact hole 24a to 24h that expose the other ends of the first to the eighth underlying conductive lines 14a to 14h are formed on the second insulating layer 20. Next, a layer of metal material is formed on the oxide film 16 to cover the contact holes and then is patterned, thereby forming a first upper conductive line 26a which is connected to the one end of the first underlying conductive line 14a through the first contact hole 22a and is also connected to the other end of the second underlying conductive line 14b through the ninth contact hole 24a; a second upper conductive line 26b which is connected to the one end of the second underlying conductive line 14b through the second contact hole 22b and is also connected to the other end of the third underlying conductive line 14c through the tenth contact hole 24c; a third upper conductive line 26c which is connected to the one end of the third underlying conductive line 14c through the third contact hole 22c and is also connected to the other end of the fourth underlying conductive line 14d through the eleventh contact hole 24d; a fourth upper conductive line 26d which is connected to the one end of the fourth underlying conductive line 14d through the fourth contact hole 22d and is also connected to the other end of the fifth underlying conductive line 14e through the twelfth contact hole 24e; a fifth upper conductive line 26e which is connected to the one end of the fifth underlying conductive line 14e through the fifth contact hole 22e and is also connected to the other end of the sixth underlying conductive line 14f through the thirteenth contact hole 24f; a sixth upper conductive line 26f which is connected to the one end of the sixth underlying conductive line 14f through the sixth contact hole 22f and is also connected to the other end of the seventh underlying conductive line 14g through the fourteenth contact hole 24g; a seventh upper conductive line 26g which is connected to the one end of the seventh underlying conductive line 14g through the seventh contact hole 22g and is

also connected to the other end of the eighth underlying conductive line 14h through the fifteenth contact hole 24h; and a metal pad 30 connected to the one end of the eighth underlying conductive line 14h for applying an external signal (FIG. 4).

At this time, the first to the eighth underlying conductive lines 14a to 14h and the first to the seventh upper conductive lines 26a to 26g constitutes a single inductor coil.

FIG. 5 is a sectional view of a conventional conductor taken along line a-a' of FIG. 4, wherein the same reference numerals as those explained by reference to FIGs. 1 to 4 indicate same components.

The one end of the second underlying conductive line 14b is connected to the second upper conductive line 26b, and the other end thereof is connected to the first upper conductive line 26a.

According to the above-referenced U.S. Patent No. 3,614,554, there are two disadvantages as follows.

Firstly, when the line width of the conductive line of the inductor coil is made fine, the value of self-induction L is reduced due to the reasons explained in detail below even though the thickness of the oxide film 16 and the second insulating layer 20 is constant.

In case of inductor coil that is winded in N numbers on a magnetic material having a non-magnetic permeability of   and a sectional area of S, when current I flows through the inductor coil, a magnetic field H is generated, and the self-induction L of this time is given as Equation 1.

$$L= N \quad sHS/I \text{ ------------ Equation 1}$$

When the two inductors are consisted, the mutual inductance value is expressed as Equation 2, wherein i is current, V is voltage,   is magnetic flux density, n is the number of

winding.

------------- Equation 2

According to the above Equation 1, the self-induction L is proportional to the sectional area S inside the coil. Here, assuming that the length of the semiconductor device 10 in a direction in parallel with the bar 18 is "a" and the vertical directional length of the contact hole is "b" (see b in FIG. 5), it becomes S = a x b.

At this time, according to the above-referenced U.S. Patent No. 3,614,554, the "a" is related to the size of the design which the inductor occupies, and the "b" is determined by the sum of the thickness of the oxide film 16 and the second insulating layer 20. However, even though the thickness of the oxide film 16 and the second insulating layer 20 is constant, the "a" value may be depended upon the state of the inductor coil, wherein in case that the line width of the underlying conductive line and the upper conductive line both constituting the inductor coil is fine, for example less than 0.5 m, the "b" value is constrained since it is relatively dependent on the line width, thus it functions as a factor of reducing the L value.

Secondly, This is because that the inductor coil disclosed in the above-referenced U.S. Patent No. 3,614,554 is not circularly winded. In other words, in case that the inductor coil is not circular, a continuous change of the magnetic field cannot be made since an abrupt change of the magnetic field is generated at the portion where the coil is bent (see A in FIG. 5).

## SUMMARY OF THE INVENTION

It is an object of the present invention to solve the problems involved in the prior art, and to provide a semiconductor device including inductors which can increase easily the value of self-induction and is capable of maintaining the change of the magnetic field uniformly.

It is another object of the present invention to provide the most suitable method of making the inductor.

In order to accomplish the above-objects, a semiconductor device including inductors according to the present invention comprises: an insulating layer formed on a semiconductor substrate; a semicircle columnar groove formed in said insulating layer; a cylindrical insulator formed on said groove; and inductors of a spring shape having underlying conductive lines formed between said insulator and said groove, and having upper conductive lines being contacted with the underlying conductive lines.

The underlying conductive lines are slantly longitudinally formed with a predetermined distance therebetween along the groove, the underlying conductive lines being formed across the groove, the upper conductive lines are slantly longitudinally formed with a predetermined distance therebetween along the groove, the upper conductive lines being formed across the groove.

The upper conductive lines are formed to connect their one end with one end of the underlying conductive lines, respectively and to connect their other end with the other end of the underlying conductive lines, respectively.

The semiconductor substrate is any one of silicon substrate and compound semiconductor substrate such as gallium arsenide etc. The entire surface of the underlying conductive lines except for the portions connecting with the upper conductive lines is covered with an oxide film and an oxidization prevention layer in order.

A method of making a semiconductor device including inductors according to the present invention comprises the steps of; forming a semicircle columnar groove in an insulating layer on a semiconductor substrate; forming underlying conductive lines with a predetermined distance therebetween on the groove; forming a cylindrical insulating layer in the groove

formed with the underlying conductive lines and on the surface of the substract; and forming upper conductive lines on the insulating layer to contact with said underlying conductive lines.

The step of forming the groove further comprises the steps of: forming a nitride film on the insulating layer; forming a photosensitive film pattern for exposing the nitride film for a groove; etching the nitride film by using the photosensitive film pattern as a mask to be exposed the insulating layer for forming the groove; and etching the exposed insulating layer.

The underlying conductive lines are slantly longitudinally formed along said groove to across.

A method of making a semiconductor device including inductors further comprises the steps of: forming an insulating layer on the surface of the underlying conductive lines; covering the entire surface of the substrate formed with the insulating layer with an oxidization prevention layer; and

buring bury material between the upper conductive lines in the groove.

A method of making a semiconductor device including inductors further comprises the step of forming a contact region by etching the insulating layer and the oxidization prevention layer for connecting the underlying and upper conductive lines after the buring step.

The step of forming the insulating layer comprises the steps of; laminating an oxidizable material on the entire surface of the substrate to thereby be entirely buried the groove; and forming the insulating layer on the surface of the substrate and the groove by oxidization of the oxidizable material.

The step of filling the groove with oxidizable materials further comprises the steps of: laminating oxidizable materials on the entire of the substrate to thereby buried the groove; and etching the oxidizable materials to fill only in the groove.

A semiconductor device including inductors according to the present invention comprises:

a semicircle groove formed in an insulating layer on a semiconductor substrate; a magnetic core formed on the groove; and inductors having a spring shape and having underlying conductive lines formed between the magnetic core and the groove, and upper conductive lines formed on the magnetic core to thereby contact with the underlying conductive lines.

The underlying and upper conductive lines are formed of aluminum or copper having low resistance value.

The oxide film is formed between the substrate and the underlying conductive lines, and between the underlying conductive lines and the upper conductive lines.

A method of making a semiconductor device including inductors comprises the steps of: forming a semicircle groove in an insulating layer on a semiconductor substrate; forming underlying conductive lines with a predetermined distance therebetween to across groove; forming a magnetic core in the groove formed with the underlying conductive lines; and forming upper conductive lines on the magnetic core, the upper conductive lines being contacted with the underlying conductive lines.

The step of forming groove comprises the steps of; forming an oxide film as a relief region on the substrate; forming a silicon nitride layer and an oxide film in high temperature on the oxide film; forming a trench by etching the oxide film, silicon nitride layer and oxide film in high temperature; forming an oxide film on the entire surface of the substrate; forming an semicircle groove by wet-etching the oxide film; and removing the oxide film, silicon nitride layer and oxide film in high temperature.

The step of forming underlying conductive lines comprises the steps of; forming an oxide film on the entire surface of the substrate; forming a conductive material on the oxide film; and forming underlying conductive lines with a predetermined distance therebetween along

the groove by patternizing the conductive material.

The step of forming the magnetic core comprises the steps of; forming an oxide film, a magnetic material and a capping oxide layer in order on the substrate formed with the underlying conductive lines; forming the magnetic core in the groove by patternizing the magnetic material; and wrapping the magnetic core with the oxide film by forming a spacer at both side of the magnetic core.

## BRIEF DESCRIPTION OF THE DRAWINGS

The above object, and other features and advantages of the present invention will become more apparent by describing the preferred embodiment thereof with reference to the accompanying drawings, in which:

FIGs.1 to 4 are perspective views for explaining a conventional method of making inductors of a semiconductor device.

FIG. 5 is a sectional view of a conventional inductor taken along line V-V' of FIG. 4.

FIGs. 6A and 6B are a plan view and a sectional view of a semiconductor device including inductors, which is manufactured by the method in accordance with a first embodiment of the present invention.

FIGs. 7 to 12 are process flows for explaining the method of making a semiconductor device including inductors according to the first embodiment of the present invention, where respective process flows attached "A" are sectional views and respective process flows attached "B" are plan views.

FIG. 13A and 13B are a plan view and a sectional view of a semiconductor device including inductors, which is manufactured by the method in accordance with a second embodiment of the present invention.

FIGs. 14 to 19 are process flows for explaining the method of making a semiconductor device including inductors according to the second embodiment of the present invention, where respective process flows attached "A" are sectional views and respective process flows attached "B" are plan views.

## DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

Fig. 6A is a sectional view of a semiconductor device including inductors according to the first embodiment of the present invention, and Fig. 6B is a plan view , where Fig. 6A is a plan view taken along line a-a' of Fig.6B.

The semiconductor device including inductors according to the first embodiment of the present invention, which comprises a semicircle columnar groove 38 formed in an insulating layer 32 on a semiconductor substrate 30, underlying conductive lines 40(40a-40g) longitudinally formed to intersect the groove 38 with a predetermined distance thereamong along the groove 38, a cylindrical insulator 50 formed on the groove 38, an insulator formed on the smooth substrate, upper conductive lines 54a-54f longitudinally formed to intersect the groove 38 with a predetermined distance therebetween along the groove 38, and a magnetic core 47 formed on the underlying conductive lines and the insulator 50. The upper conductive lines 54a-54f are arranged in the opposite direction of the underlying conductive lines 40.

The semiconductor device including inductors of the present invention also comprises an oxide film 42 formed on the entire surface of the underlying conductive lines 40a-40g except for the contact portion A, an oxidization prevention film 44 formed on all the surfaces of the substrate except for the contact portion A, a buried layer 46 buried in the groove 38 and a prevention film 56 formed on all surfaces of the substrate including the upper conductive lines 54.

At this time, the underlying conductive lines 40 are slantly arranged with the shortest line intersecting the groove 38 with the predetermined distance thereamong. The upper conductive lines 54 are slantly arranged to the underlying conductive lines 40 in the opposite direction with a predetermined distance thereamong so that they are connected to one end of the two neighboring underlying conductive lines. That is, the first upper conductive line 54a is connected to one end of the first underlying conductive line 40a and one end of the second underlying conductive line 40b through the contact portion A. The second upper conductive line 54b is connected to one end of the second underlying conductive line 40b and one end of the third underlying conductive line 40c through the contact portion A. The others of the upper conductive lines are connected to the underlying conductive lines, respectively as the same manner.

Therefore, both the upper conductive lines and the underlying conductive lines are formed their connecting parts as a spiral coil unlike the prior art.

In the present invention, the underlying and upper conductive lines are made of polysilicon into which impurities are doped and conductive materials such as tungsten T etc., and the semiconductor substrate 30 is made of compound, such as a silicon Si or a gallium arsenide GaAs etc.

Therefore, firstly, according to the inductors of the present invention, since the self-inductance value is not dependent on the length of the vertical direction of the contact hole for connecting the upper conductive lines and the underlying conductive lines, but is dependent on the thickness of the insulator 50, the conventional problem can be solved that the self-inductance value is relatively dependent on the line width of the conductive lines constituting a spiral coil.

Secondly, since the coil can be made the circular shape unlike the prior art, both the

underlying conductive lines and the upper conductive lines surround the insulators of a columnar shape, the conventional problem can be solved that a continuous change of magnetic field could not be made due to an abrupt change of magnetic field generated at the portion where the coil is bent (see I in FIG. 5).

FIGs. 7 to 12 are process flows for explaining the method of making a semiconductor device including inductors according to the present invention, wherein respective process flows attached "A" are sectional views and respective process flows attached "B" are plan views.

First, FIGs. 7A and 7B are sectional views after the semicircle columnar groove 38 is formed. As can be seen from the drawings, a first insulating layer 32 is formed on a semiconductor substrate 30 made of compound, such as a silicon or gallium arsenic by depositing or growing, an oxide film 32 with 10,000A of thickness. Subsequently, a silicon nitride layer 34 is formed with 1,500A of thickness on the first insulating layer 32, and a photosensitive film pattern 36 is formed on the silicon nitride layer 34 to be exposed the silicon nitride layer placed in the portion for forming a semicircle columna groove. Next, the first insulating layer 32 is exposed by etching the exposed silicon nitride layer 34 as the mask of photosensitive film pattern 36. Subsequently, the groove 38 is formed by etching the exposed first insulating layer, in which the groove is to form the spiral inductor. At this time, the first insulating layer 32 is etched by the predetermined manners, such as anisotropic etching or isotropic etching or the combined etching of anisotropic etching and isotropic etching.

FIGs. 8A and 8B are sectional views after underlying conductive lines 40 and magnetic core are formed. The photosensitive film pattern 36 and a silicon nitride layer 34 are removed and conductive material, for example, doped Poly-Si or Tungsten W is deposited on the entire surface of the substrate including the groove 38. The conductive material is patternized by a conventional method to thereby form the underlying conductive lines 40 of the inductor. The

underlying conductive lines 40 are slantly longitudinally formed with a predetermined distance therebetween along the groove 38. At this time, the underlying conductive lines 40 are formed across the groove 38. Subsequently, an oxide film 42 is formed, as a relief film, on the underlying conductive lines 40 with 150A of thickness. At this time, the oxide film 42 is formed by the manner in that the surfaces of the underlying conductive lines 40 are oxidized or the oxide film 42 is deposited or grown on the underlying conductive lines 40a-40g. An oxide prevention layer 44, such as, a nitride, is deposited with 500A of thickness on the entire surface of the substrate. Next, a buried layer 46 is formed in gaps between the underlying conductive lines 40 in the groove 38. In other words, by a etchback process a flux material, such as, spin-on glass GOS is formed with 2000A of thickness to thereby being buried the underlying conductive lines 40a-40g in the groove 38. That is, core materials, such as magnetic material or conductive material is formed on the entire of the substrate with 1000A of thickness to thereafter be formed a magnetic core 47 only in the groove 38 by wet or dry pattering.

FIGs. 9A and 9B are sectional views after a semicircle columna groove is filled with an oxidizable material to thereby be smoothed a substrate. On the entire surface of the substrate the oxidizable material 48, such as polysilicon or armorphos silicon is formed with 10,000A of thickness, and the substrate is smoothed by the performing of the GMP process or etchback process. At this time, the oxidizable material 48 is exposed until the oxidization prevention layer 44 and the buried layer 46 are exposed. Therefore, the oxidizable material 48 is divided into two parts, a portion 48a fomed on the concave portion of the groove 38 and a portion 48b formed on the smooth portion of the substrate.

FIGs. 10A and 10B are sectional views after an insulator 50 is formed by the oxidization process for the oxidizable material 48a, 48b. The oxidizable materials 48a and 48b are oxidized, to thereby form a thick oxide film 50 by oxidization of the silicon. At this time, when the

oxidization portion is oxidized, the volume thereof is expanded, and therefore the oxidization portion the thickness of which is thick forms a relative thicker insulator than an oxidization portion the thickness of which is thin. In other words, a cylindrical insulator 50 is formed by means of the first oxidization portion, and peripheral insulators 52 the thickness of which are thinner than that of the insulator 50 are formed by means of the second oxidization portion.

At this time, the oxide prevention layer 44 is maintained at exposed state since it is not oxidized.

FIGs. 11A and 11B are sectional views after a contact region A for connecting upper conductive lines (not illustrated) and underlying conductive line 40 are formed. The contact region A is formed by removing oxide films which might be formed on the oxidization prevention layer (indicated by 44 in FIG. 10) by lightly wet-etching the resulting surface of the substrate in which the insulator 50 and the peripheral insulators 52 are formed, and the oxidization prevention layer, thus exposing the underlying conductive line 40.

FIGs. 12A and 12B are sectional views after upper conductive lines 54 are formed. The doped Poly-Si or Tungsten is formed, as conductive material, on the entire surface of the substrate to thereby contact with the underlying conductive line 40 through a contact region A. Next, the upper conductive lines 54 are longitudinary formed with a predetermined distance therebetween along the groove by patternizing method for the conductive materials. At this time, the upper conductive lines 54 are formed across the groove 38 to thereby be opposite direction of the underlying conductive lines 40a-40f. The upper conductive lines 54a-54f are formed to contact their both ends with the neighboring corresponding underlying conductive lines thereto through the contact region A. Subsequently, on the entire of the upper conductive lines 54 insulating material is covered to thereby form an insulating layer 56 so that a cylindrical coil consisted of the underlying and upper conductive lines can be protected. As shown in Fig.

12B, one end of the first underlying conductive line 40a is connected to the one end of the upper conductive line 54a, and the other end of the upper conductive line 54a is connected to the other end of the underlying conductive line 40b. The same manner can be applied to the rest parts of the underlying and upper conductive lines. Furthermore, the coil is formed to have a spiral shape by assistance of the insulator 50.

FIG. 13A and 13B are a plan view and a sectional view of a semiconductor device including inductors, which is manufactured by the method in accordance with a second embodiment of the present invention.

FIGs. 14 to 19 are process flows for explaining the method of making a semiconductor device including inductors according to the second embodiment of the present invention, where respective process flows attached "A" are sectional views and respective process flows attached "B" are plan views.

As shown in Fig. 13A, a semiconductor device including an inductor according to the present invention comprises a semicircle columna groove 67 formed on the substrate 60, underlying conductive lines 71(71a-71g) slantly longitudinally arranged at a predetermined distance therebetween across the groove 67, an oxide film 72 formed on the entire of the substrate 60 including the underlying conductive lines 71 to thereby be exposed a predetermined surface of the underlying conductive lines, a magnetic core 75 formed on the oxide film 72 on the groove, upper conductive lines 54(54a-54f) slantly longitudinally formed with a predetermined distance therebetween along the groove 38. The upper conductive lines 54 are formed to contact their ends with the neighboring corresponding underlying conductive lines 71 thereto through a contact region A.

The semiconductor device according to the present invention further comprises a protection layer 86 formed on the entire surface of the substrate including the magnetic core 75 and the

upper conductive lines 54.

At this time, the underlying conductive lines 71 are, as shown in Fig. 13B(71a-71g), consisted of a plurality of conductive lines which are formed to run counter with the nearest line acrossing the groove 100. Furthermore, the upper conductive lines are, as shown in Fig. 13B(80a-80f) consisted of a plurality of conductive lines which are formed to contact their ends with the ends of the neighboring corresponding underlying conductive lines thereto. Therefore, the underlying and upper conductive lines are formed to have a circular coil shape unlike the conventional method.

On the surface of the underlying conductive lines except for the connecting parts with the an oxide film 72. The underlying and upper conductive lines according to the present invention are formed by conductive material, such as the doped-polysilicon Poly-Si or tungsten T, and substrate 60 is made of compound, such as silicon or galluim arsenic GaAs.

Therefore, according to the present invention the problems having the prior art can be solved since self-inductance value does not depend the longitudinal length of the contact region for connecting the underlying conductive lines and the upper conductive lines, but the thickness of the insulator 50.

Furthermore, it is possible to form a circular coil since the underlying and upper conductive lines are formed to enclose the insulator.

FIGs. 13 to 19 are process flows for explaining the method of making a semiconductor device including inductors according to the second embodiment of the present invention, where respective process flows attached "A" are sectional views and respective process flows attached "B" are plan views.

Figs. 14A, 14B and Fig. 15A, 15B are sectional views for forming a semicircle columna groove for a spiral coil. Figs. 14A and 15A are sectional views taken along with the lines a-a'

and a-a', respectively.

On a semiconductor substrate 60 made of compound, such as silicon and Ga, an oxide film 62 for relief is grown with 500A of thickness and a silicon nitride layer 64 and an oxide film in high temperature 66 are formed with 7000A of thickness.

Subsequently, the oxide film 66 in high temperature, the silicon nitride layer 64 and the oxide film 62 are all etched and the substrate 60 is etched by 3 to 5μm of thickness to thereby form a trench 67a.

To form a groove having a semicircle shape although it is not shown in drawings, the oxide film in the trench 67a is grown to thereafter be removed, and the oxide film is formed with 1μm of thickness to thereby be removed by wet etching. And, the oxide film 66 in high temperature, the silicon nitride layer 64 and the oxide film 62 for relief are removed to thereby form a groove having the semicircle shape.

Figs. 15A and 15B are sectional views after the underlying conductive lines are formed.

After an oxide film 66 in high temperature, a silicon nitride layer 64 and an oxide film 62 are removed, an oxide film 68 is grown with 2000A of thickness for insulating an inductor therefrom on the groove 67. Subsequently, conductive material 70, such as the doped Poly-Silicon or Aluminum or Copper having low resistance value is formed with 2μm of thickness.

Figs. 16A and 16B are sectional views after the underlying conductive lines are formed.

In Figs. 16A and 16B, a conductive material 70 is patternized by using a photosensitive film pattern (not shown) to thereby form underlying conductive lines 71(71a-71g). At this time, the underlying conductive lines 71 are slantly longitudinally formed with a predetermined distance therebetween along the groove 67 to thereby across the groove 67.

An oxide layer 72 for insulating the internal of the inductor is formed with 5000A of thickness. Subsequently, a core material 74, such as magnetic material or conductive material is

formed on the oxide film 72 to thereafter be performed GMP process for smoothing the core material. Subsequently, a capping oxide layer 76 is formed with 5000A of thickness on the surface of the smoothed core material 72.

Figs. 17A and 17B are sectional views after a magnetic core is formed.

The magnetic core 75 is formed by patternizing both the core material 74 and the capping oxide layer 76 by using the photosensitive film pattern not shown. An oxide layer is formed with 5000A of thickness to thereafter be anisotropic-etched to be formed a spacer 78. Therefore, the magnetic core 75 is definitely isolated by the oxide films 72, 76 and 78.

Figs. 18A and 18B are sectional views after upper conductive lines are formed.

First, an oxide film 72 is etched to form a contact hole C in order to be exposed both sides of the underlying conductive lines 71.

The upper conductive lines 80(80a-80f) are formed with the same conductive material as the underlying conductive lines.

At this time, the upper conductive lines 80 are slantly longitudinally formed to across the groove 67, in the opposite direction of the underlying conductive lines to thereby contact the both ends thereof with the neighboring corresponding underlying conductive lines 71 thereto through the contact hole C.

Subsequently, on the entire surface of the substrate formed with the upper conductive lines 80 is covered with insulating material to thereby form an insulating layer 82. Next, a metal wire 84 is formed. The metal wire 84 is formed only at both ends of the underlying conductive lines if the inductor has a constant value, and may be formed every underlying conductive lines if the inductor has not a constant value.

At this time, one end of the underlying conductive line 71a is connected to one end of the upper conductive line 80a. The other end of the upper conductive line 80a is connected to

the other end of the underlying conductive line 71b. The same manner is applied to the rest parts of the underlying and upper conductive lines.

Furthermore, it can be seen that a coil consisting of the underlying and upper conductive lines 71, 80 which are connected therebetween through the contact hole C is formed to have a spiral shape.

Figs. 19A and 19B are sectional view and plane view, respectively according to the third embodiment of the present invention.

In the drawings, the two grooves 67 are formed for an inductor which is consisted of upper conductive lines 80(80a-80g), 80˜(80a'-80g') and underlying conductive lines 71(71a-71g), 71(71a'-71g').

It can be also understood that the coil, which is consisted of the underlying conductive lines and the upper conductive lines, is formed to have a spiral shape which does not have any angled portion caused by the insulator 50.

As described above, according to the present invention, the change of magnetic field can be constantly maintained since the inductors can be made spiral shape and the increasement of self-induction value can be also facilitated since the thickness of the insulator and the positional density of the conductive lines can be freely controlled.

While the present invention has been described and illustrated herein with reference to the preferred embodiment thereof, it will be understood by those skilled in the art that various changes in form and details may be made therein without departing from the spirit and scope of the invention.